



# Instruction Manual

**MODEL #X3645**

## High Voltage Power Supply

**MODEL :X3645**

**SERIAL# :**

**DATE :7/11/05**

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## IMPORTANT SAFETY PRECAUTIONS

### SAFETY

THIS POWER SUPPLY GENERATES VOLTAGES THAT ARE DANGEROUS AND MAY BE FATAL.  
OBSERVE EXTREME CAUTION WHEN WORKING WITH THIS EQUIPMENT

High voltage power supplies must always be grounded.

Do not touch connections unless the equipment is off and the Capacitance of both the load and power supply is discharged.

Allow five minutes for discharge of internal capacitance of the power supply.

Do not ground yourself or work under wet or damp conditions.

### SERVICING SAFETY

Maintenance may require removing the instrument cover with the power on.

Servicing should be done by qualified personnel aware of the electrical hazards.

**WARNING** note in the text call attention to hazards in operation of these units that could lead to possible injury or death.

**CAUTION** notes in the text indicate procedures to be followed to avoid possible damage to equipment.

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# 1 INTRODUCTION

## 1.1 DESCRIPTION OF THE DF/FF SERIES

This series of high voltage power supplies represents a radically new advanced approach to X-ray generator power requirements. These power supplies provide all of the power, control, and support functions required for practically all X-ray diffraction (XRD) or X-ray fluorescence (XRF) applications. The DF/FF series provides high voltage, high current outputs with very low ripple. Extremely stable voltage and current outputs result in significant performance improvements over previously available technology. Low output ripple provides higher intensity levels, with no increase in tube loading.

All of these advancements are possible only by Spellman's long history in X-ray power systems. This series of power supplies utilizes extremely advanced quasi-resonant PWM conversion techniques, along with sophisticated digital technology.

The DF series is specifically designed for XRD X-ray tube applications. The high voltage is a negative polarity, and the filament circuits are referenced to the cathode high voltage potential, (floating filament). The FF series is specifically designed for XRF X-ray tube applications. The high voltage is a positive polarity, and the filament circuits are referenced to cathode ground potential, (grounded filament).

The X-ray tube voltage, tube emission current, tube filament current limit, and maximum tube power, are all

continuously adjustable via analog remote controls or digitally over RS-232 interface (optional).

The power supplies operate from a variety of line voltages and are fan-cooled, requiring no water-cooling. Custom designed units for single use or OEM applications are available.

## 1.2 STANDARD FEATURES

The DF/FF series incorporates extensive standard features designed to optimize user control and safety.

**KV AND MA/FILAMENT CURRENT RAMP CIRCUITS:** This feature provides for a gradual rise for kV, mA, and filament current. This feature is designed to limit voltage shock and filament shock to the X-ray tube. The kV ramp rate is approximately 30 seconds. The filament current is slowly increased until the desired mA level is achieved. This time is typically 30 seconds for full mA output. These ramp conditions are started at the initial X-RAY ON control signal or when the kV control, (front panel potentiometer or remote programming), drops below the kV MIN level. The kV MIN level is typically set at 8kV. The kV MIN level is adjustable by an internal resistor valve. Other kV MIN levels can be accommodated. Consult Spellman Engineering for further information.

**FAIL-SAFE, DUAL INDICATOR LAMPS:** The X-ray on lamp utilizes a sensing circuitry for detecting proper operation of the lamp for the indicator. If the X-ray on lamp is not functioning, the power supply will not generate high voltage. If the X-ray on lamp is depressed and the indicators do not illuminate, the

lamps are defective and should be replaced in order to generate high voltage. Control power and X-ray off lamps are also dual type lamps for added reliability. This should go out, or appear in a different form.

**INTERNAL FAULT PROTECTION AND DIAGNOSTICS:** The DF/FF series continually monitors internal circuits critical to the proper operation of the power supply and X-ray tube. The diagnostic programming is a software based, decision-making technology. Flexible software provides very sophisticated decision-making capabilities within the power supply. Also, a variety of user configurations can be achieved by custom software written by Spellman Engineering. If a specific fault condition or diagnostic is required, consult Spellman High Voltage Engineering Department.

### **1.2.1 REMOTE OPERATING FEATURES**

**REMOTE PROGRAMMING:**

Allows remote adjustment of the output voltage, output current, filament current limit, and maximum tube power via an external voltage source.

**REMOTE MONITOR:** Allows remote monitoring of the output voltage and output current.

**REMOTE X-RAY ON/OFF**

**CONTROL:** Allows remote control of X-ray ON and X-ray OFF functions. Signals are also provided for remote indication of X-ray ON status. This can be used for a variety of water control or remote lamp functions.

**REMOTE POWER ON:** Allows remote control of Control Power ON/OFF function. This feature also

allows remote reset of the power supply in case of a fault shutdown.

**EXTERNAL INTERLOCK:** Interlock connections are provided for a variety of water flow and safety functions. The unit will not operate unless the interlock is closed. Opening the interlock circuit will cause the unit to shut off.

**REMOTE STATUS SIGNALS:** A variety of power supply status signals are available on the remote interface. These signals are open collector type. Over current, over voltage, filament limit, overpower, and power supply fault status signals are available from the remote interface. Other signals can be supplied as required.

**REMOTE FAIL-SAFE INDICATOR**

**LAMP:** A remote signal is available for connection to an external X-ray ON indicator lamp. This circuit senses proper operation of the external lamp and will shut down high voltage if the lamp is open. 12V-24Vdc or 220Vac lamps can be accommodated. 24Vdc is standard, other voltages may be specified when ordering.

**REMOTE WATER SOLENOID**

**CONTROL SIGNAL:** A signal is provided for energizing a remote water solenoid for X-ray tube water flow requirements. This signal can be provided when the control power is energized or when X-ray ON is energized. 24Vdc energized with X-ray ON is standard, 220Vac switched is also provided. See 1.3 for optional configurations.

**DUAL FILAMENT SUPPLY**

**INTERFACE:** An optional dual filament power supply is available. This chassis interfaces to the DFFF power supply.

Consult Spellman's Sales Department for details.

### **1.2.2 SYSTEM STATUS AND FAULT DIAGNOSTIC DISPLAY**

Dead front type indicators are provided to give the user indication of system operation and fault conditions. If a fault occurs, the power supply will shut down. To reset, toggle the CONTROL POWER ON switch, or use the reset function on remote user interface.

**INTERLOCK CLOSED:** Indicates the EXTERNAL INTERLOCK connections are in the closed position.

**INTERLOCK OPEN:** Indicates the EXTERNAL INTERLOCK connections are in the open position.

**OVER VOLTAGE:** Indicates the over voltage protection circuitry has caused the power supply to turn off. Over voltage is internally set to 105%-110% of rated output voltage.

**OVER CURRENT:** Indicates the output current has exceeded 10% of rated output current. The over current level is internally set.

**OVER POWER:** indicates the output power has exceeded the front panel or remote programmed power trip level.

**ARC:** Indicates that a tube arc has occurred.

**KV RGLT ERROR:** Indicates that the high voltage regulation circuit cannot maintain voltage regulation. This may occur if the input voltage is too low.

**MA RGLT ERROR:** Indicates that the tube emission current regulation circuit error cannot maintain current regulation. This may occur when tube filament problems exist.

**FILAMENT CURRENT LIMIT:** Indicates that filament current has exceeded the programmed filament current limit trip level.

**KV MIN:** Indicates the minimum KV level is not being programmed. This indicator will illuminate for approximately 10 seconds before shut down. This provides protection of the tube filament. The KV min circuitry also resets the KV and MA/filament ramp circuits. When the voltage is programmed higher than the kV min level, the outputs will begin the ramp cycle.

**LEAKAGE LIMIT/TEMP:** On the DF/FF power supply, a tube leakage current detection circuit is provided. Shut down will occur if leakage current exceeds 5mA. A test point on the rear panel is also provided for test purposes. LED LEAKAGE/TEMP will blink at approximately 0.5Hz frequency. Temperature is constantly monitored inside the unit. Shut down will occur if temperature exceeds safe operating level. Steady illumination on LEAKAGE/TEMP front panel LED will indicate over temperature condition.

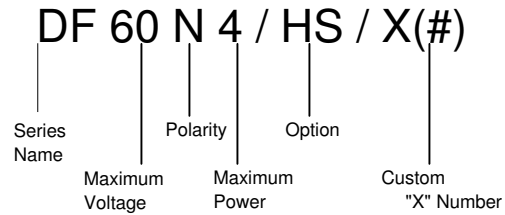
**OPEN FILAMENT:** Indicates the X-ray tube filament or connections to the filament are open.

## **1.3 OPTIONS:**

The options available are listed in Table 1.1. See Section 5 for more information on these options along with operating and

set-up instructions. With few exceptions, these options can be retrofitted to your power supply at the factory in a short time. For price and retrofit arrangements, contact the Spellman Sales Department.

The model number of the power supply describes its capabilities. After the series name is:



## 1.4 INTERPRETING THE MODEL NUMBER

OPTION CODE	OPTION
3 PH	208Vac, $\pm 10\%$ , 3 phase, 50/60Hz input
HS	20ppm Temperature Coefficient (voltage and current)
FSI (220V)	Remote Fail-Safe circuit operating at 220Vac (replaces WFS 220V standard circuit)
FSI (12VDC)	Remote Fail-Safe circuit operating at 12Vdc (24Vdc standard)
WFS (24V/PO)	24Vdc water flow signal switched with power ON (switched with X-Ray ON is standard)
WFS (220V/PO)	220V ac water flow signal switch with power ON (switched with X-Ray ON standard) *Not available with FSI (220V)
DFS	Dual Filament supply (DF/FF-F Only)
JP	180Vac/220Vac 60kV/150mA/4kW maximum output power
ETM	Elapsed time meter – displays cumulative hours of X-Ray ON <b>(in micro)</b>
LC	LC jumped together on X-Ray output connector (LS jumped is standard)
SL	Mounting Slides
SS(X)	Non-standard slow start (this should go out)

Table 1.1

## **2 INSPECTION & INSTALLATION**

Initial inspection and preliminary checkout procedures are recommended. For safe operation, please follow the step-by-step procedures described in Chapter 3, Operating Instructions.

### **2.1 INITIAL INSPECTION**

Inspect the package exterior for evidence of damage due to handling in transit. Notify the carrier and Spellman immediately if damage is evident. Do not destroy or remove any of the packing material used in a damaged shipment.

After unpacking, inspect the panel and chassis for visible damage. Fill out and mail the Warranty Registration card accompanying the unit. Standard Spellman DF/FF High voltage power supplies and components are

covered by warranty. Custom and special order models (with an X suffix in the model number) are also covered by warranty.

### **2.2 MECHANICAL INSTALLATION**

Units in the DF/FF series have front panel holes for standard EDI rack mounting. The rack must allow rear access for cable connections. Units are fully enclosed and are suitable for bench or tabletop operation. Standard unit dimensions are shown in Figure 2.1. It is strongly recommended to support the chassis by guides or slides. Slides are available for ease of servicing of the internal assemblies (SL option).





# 3 OPERATING INSTRUCTIONS

## 3.1 OPERATION

### WARNING

**THIS EQUIPMENT GENERATES DANGEROUS VOLTAGES THAT MAY BE FATAL. PROPER GROUNDING OF ALL HIGH VOLTAGE EQUIPMENT IS ESSENTIAL.**

### IMPORTANT:

**Before connecting the power supply to the AC line, follow this step-by-step procedure.**

**Do not connect the power supply to the AC line until Step H is reached.**

**Failure to follow these procedures may void the warranty.**

A) Insure that the CONTROL POWER ON switch on your remote interface fixture is in the OFF (out) position.

B) Check the input voltage rating on the nameplate of the supply and make certain that this is the rating of the power source to be connected. Units operate on 220VAC single phase, unless ordered with a different input voltage.

C) Proper Grounding Technique: The chassis of the high voltage power supply must be grounded to the local earth ground and also to the tube housing ground. See Figure 3.2 for typical operating setup.  
A three-wire cable is provided for connecting to the AC supply. The Green wire is for chassis safety ground connection.

D) Connect the X-ray cable to the X-ray tube housing.

E) Connect the X-ray cable to the power supply. Insure the connector and housing is clean. Generally vacuum grease or oil is not required but can be used if desired. Tighten the cable collar to the connector housing.

F) Options Note: See Section 5 for hook up and operating instructions for the options on your unit. Custom models may also require set-up changes.

G) For initial turn on, set the kilovolt control voltage to the zero position.

H) The input power cable may now be connected to the AC power source.

I) Turn CB1 to the ON position. The power supplies have internal circuit protection (circuit breaker). It is good practice to provide external circuit protection also. Depending on input voltage requirement, the line current requirements will vary. Typically, a 50Amp service is advised. If unsure of service requirements, consult Spellman's Engineering Department.  
CB1 can now remain in the ON position and power can be turned ON and OFF via the remote control power ON switch.

Depress the Control Power ON switch. The "+24V POWER ON" LED will illuminate. One of the Interlock closed-open LEDs will illuminate displaying status of external interlock connections.

J) Presetting: The kV, mA, filament current limit and maximum tube power

limit can now be preset via remote control fixture. It is suggested to set kV to a minimum value, (10kV-20kV). If kV level is set too low, the kVMIN indicator will illuminate. Simply raise the kV level if this occurs. Set mA level to a minimum value (5mA). Filament current and tube power limit should be set as required by the X-ray tube manufacturer.

K) X-ray ON: After presetting desired levels, depress and release the X-ray ON switch. The X-ray ON indicator will

illuminate. The remote X-ray lamp will also illuminate. KV and mA will ramp to set levels as controlled by internal ramp circuits. Once kV and mA levels are reached, (4-30 seconds) adjust kV and mA for desired output.

L) To terminate the generation of X-rays, depress the X-ray OFF switch.

M) To turn off the power supply, depress the Control Power ON Switch (out).

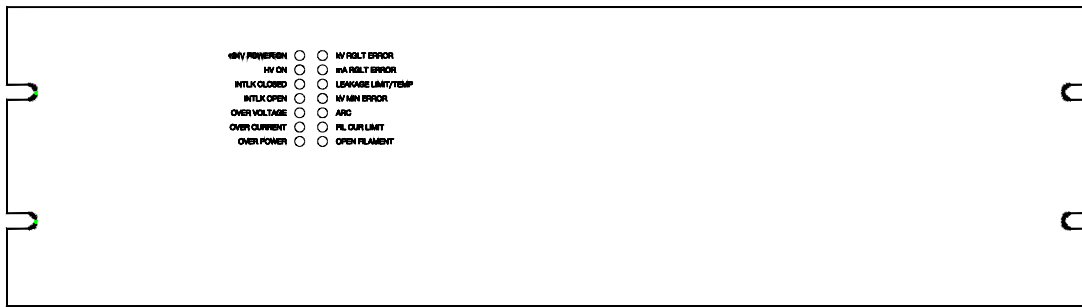


Figure 3.1 DF/FF Front panel layout

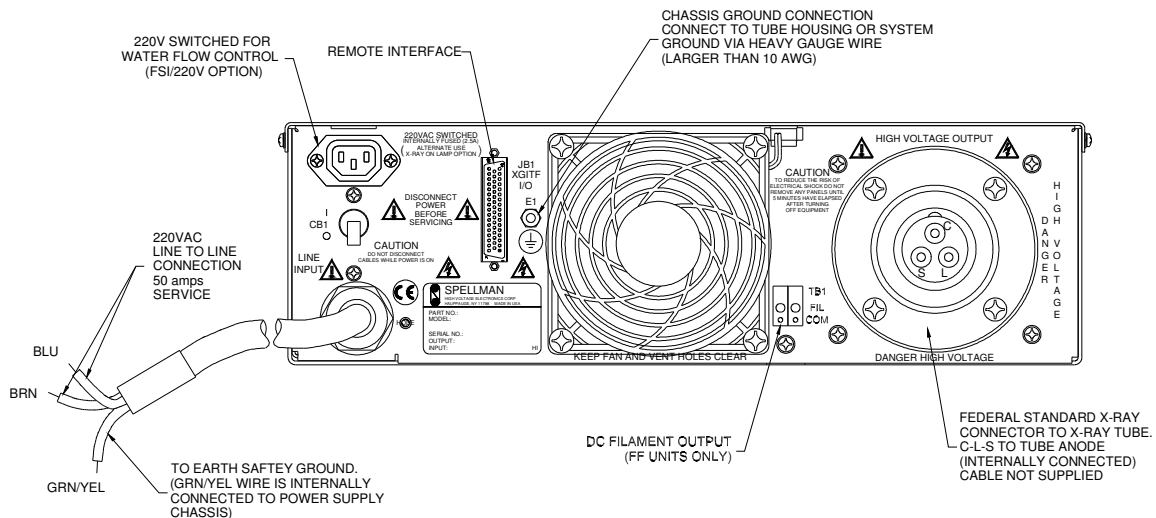


Figure 3.2 DF/FF Rear panel layout

### Important

#### WARNING

**AFTER TURN OFF, DO NOT UNPLUG THE OUTPUT CABLE UNTIL THE INTERNAL CAPACITANCE IS DISCHARGED (APPROXIMATELY 1 MINUTE).**

#### WARNING

**The voltmeter on the power supply front panel does not read the output voltage when the Control Power is turned off, even if a charge still exists on the load.**

#### CAUTION

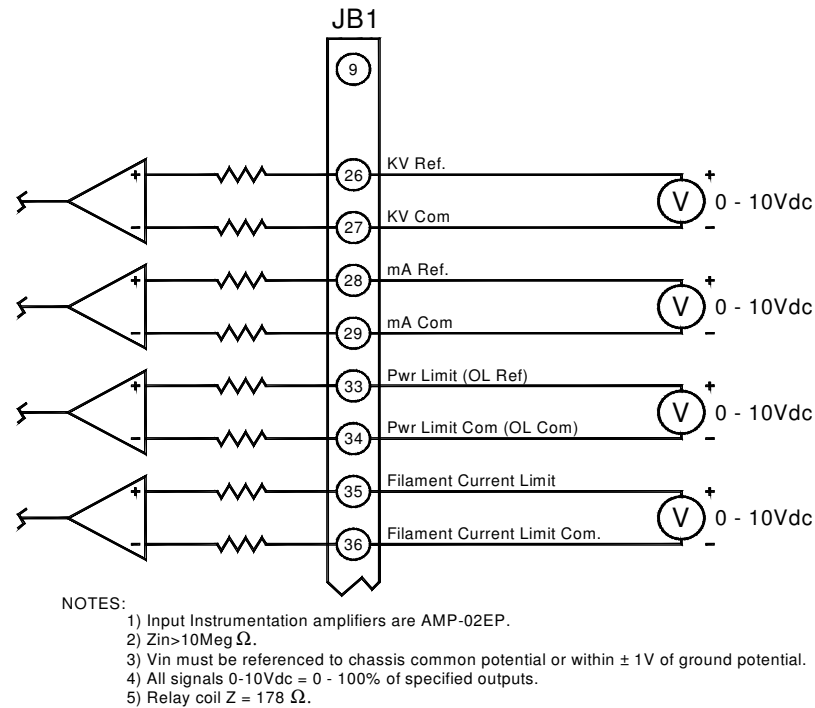
**Always operate the unit with the cover on. A fan maintains safe operating temperature in the power supply by drawing air over critical components. The cover must be on in order to direct the airflow over the areas that need cooling.**

*In operation, the unit must be placed so that the air intake and the fan exhaust are clear of any obstruction that might impede the flow of air.*

### 3.2 STANDARD FEATURES:

A note on remote interface circuitry and remote signal grounding:

Whenever possible, electrical isolation should be provided when interfacing with any high voltage power supply. For remote control signals such as POWER ON/OFF, X-RAY ON/OFF, EXTERNAL INTERLOCK, etc., isolated power and grounding from the power supply should be used. The DF/FF series provides isolated relay coils for the above signals. (See suggested interface).



**Figure 3.3 Remote programming interface**

Other digital status signals provided on the DF/FF series should be interfaced using opto-isolators. If possible, analog signals should be isolated via analog isolation amplifiers. All interface cables

### 3.2.1 PROGRAMMING:

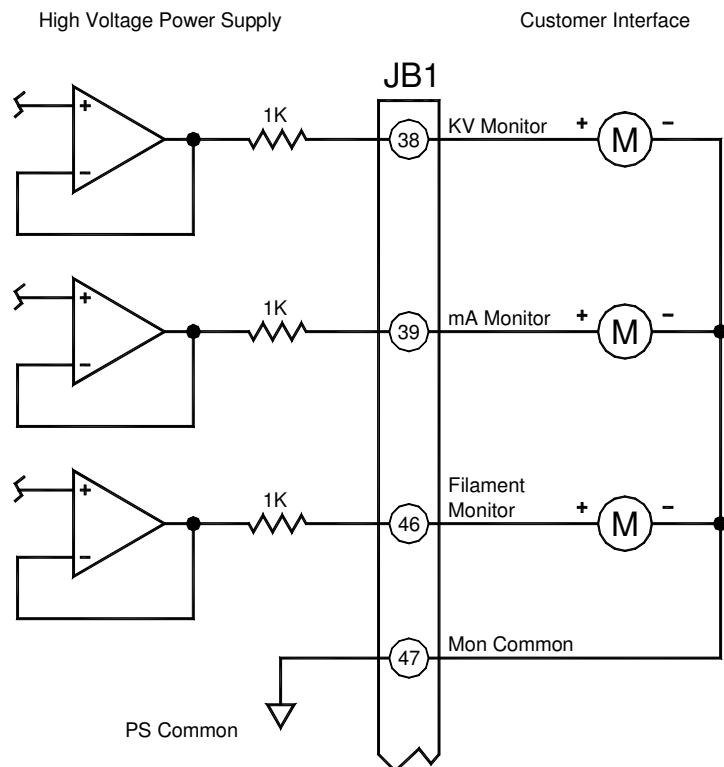
Allows remote adjustment of the tube voltage, tube current, filament current limit, and maximum tube power limit, via external voltage source.

For remote program, a positive voltage source from 0 to 10V = 0-100%, is applied to the appropriate terminals on the rear panel 50-pin D connector. By adjusting the voltage source from 0 volts (zero output) to 10 volts (full rated output) the desired output can be selected. See Figure 3.3 for wiring diagram and

should be properly shielded. All power supply signals should be referenced to the power supply chassis ground. Spellman application engineers are available to assist in interface circuitry design. specifications for remote program interface requirements.

### 3.2.2 MONITOR:

Test points are made available at the rear 50-pin connector from monitoring tube voltage, tube current and tube filament current. Also, tube voltage programming and tube current programming readback signals are provided. The test points are always positive regardless of the output polarity, where 0 to 10V = 0-100% of output. Accuracy is within  $\pm 0.5\%$ . All test points have output impedance at 1Kohm. Figure 3.4 for remote monitor interface.



NOTES:

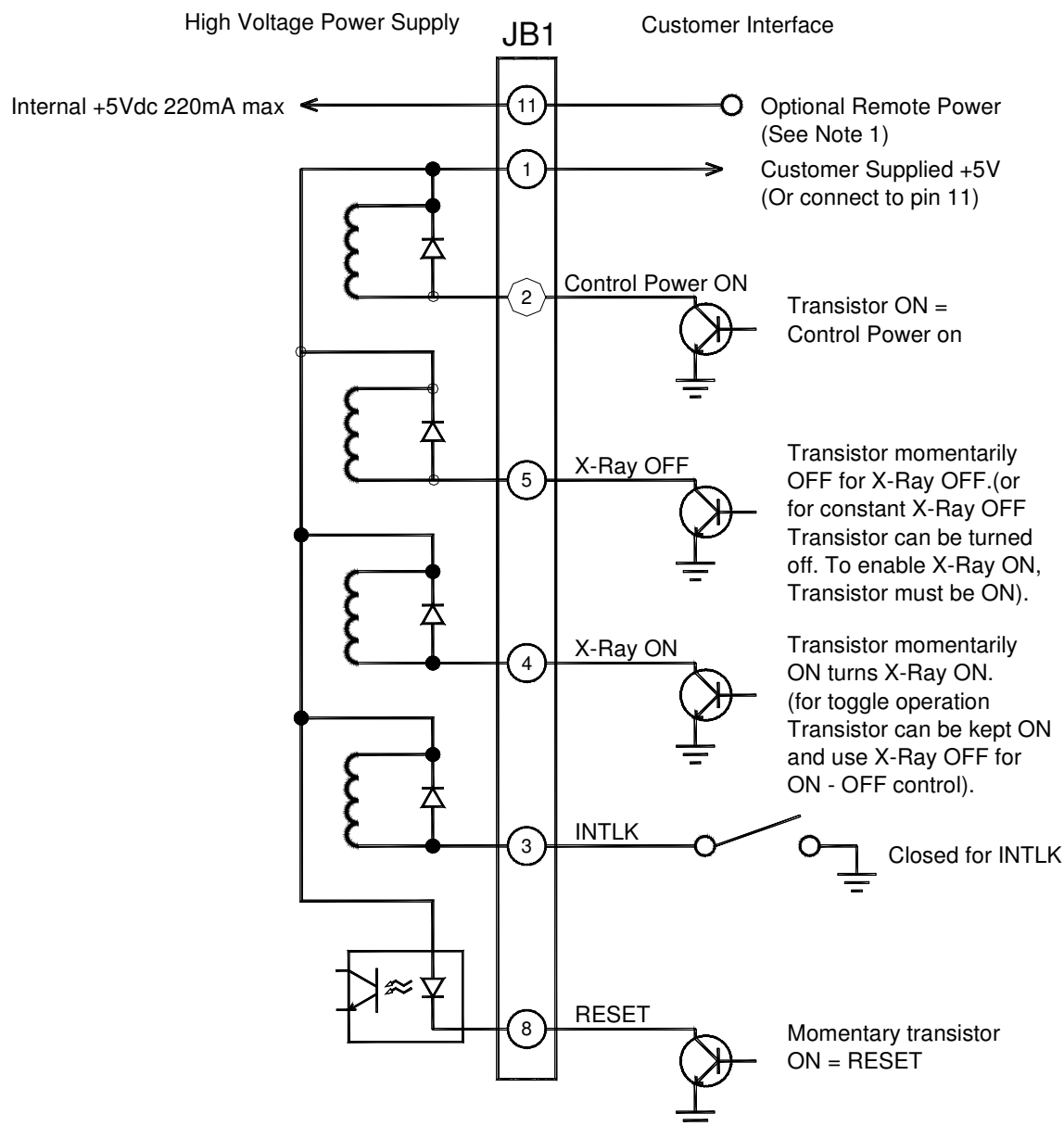
- 1) Metering Circuit should be high Z type (>10 Meg) for accurate measurement.
- 2) All signals 0 - 10Vdc = 0 - 100% of specified maximum outputs.

**Figure 3.4** Remote monitoring interface

**3.2.3 CONTROL:**

Remote control of the POWER ON, X-RAY OFF, X-RAY ON, and INTERLOCK, are available on the rear 50-pin connector. The POWER ON control is a toggle on/off type signal. X-RAY OFF and X-RAY ON are controlled by momentary normally closed and

normally open contacts respectively. If remote control is required, the remote interface dummy plug must be removed and replaced with the appropriate remote circuits. See Figure 3.5 for recommended interface circuits.



NOTES:

- 1) The power supply provides +5Vdc for coil voltage, however for full isolation, an external customer supplied +5Vdc power is suggested.
- 2) Relay coil  $Z = 178 \Omega$ .
- 3)  $\perp$  should be referenced to chassis ground.
- 4) Relay contacts or switches can be used instead of transistors.

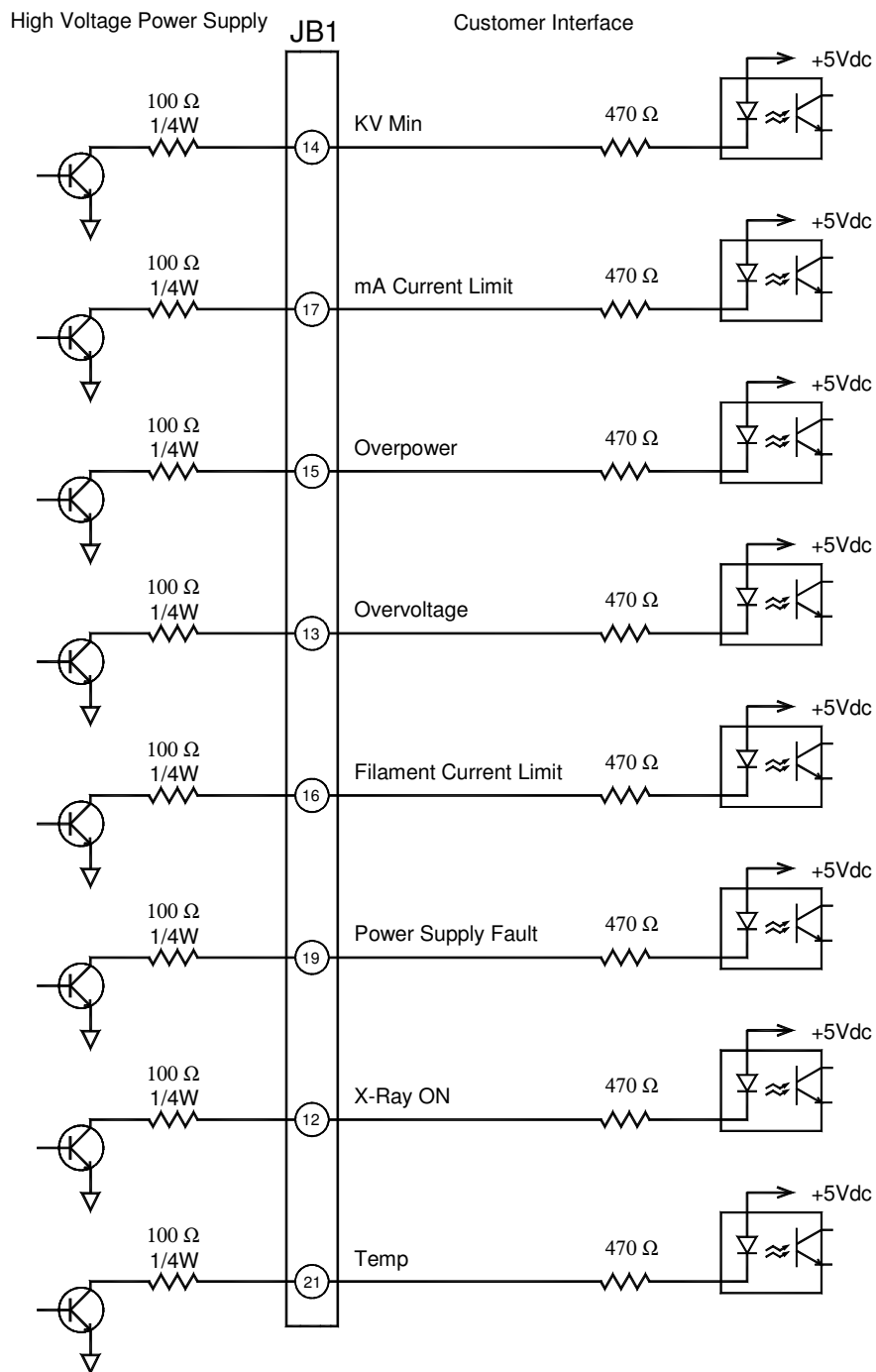
**Figure 3.5** Remote control interface

#### **3.2.4 STATUS:**

Remote status signals for KV MIN tube current limit, tube power limit, overvoltage, filament current limit, overtemp, leakage current limit and power

supply fault is provided. These signals are open collector type. (Normally off), and are intended to drive the diode of an opto-coupler. See Figure 3.6 for recommended interface circuits.





- NOTES:
- 1) 100 mA max collector current on internal power supply transistors.
  - 2) Low level on transistor = status active.

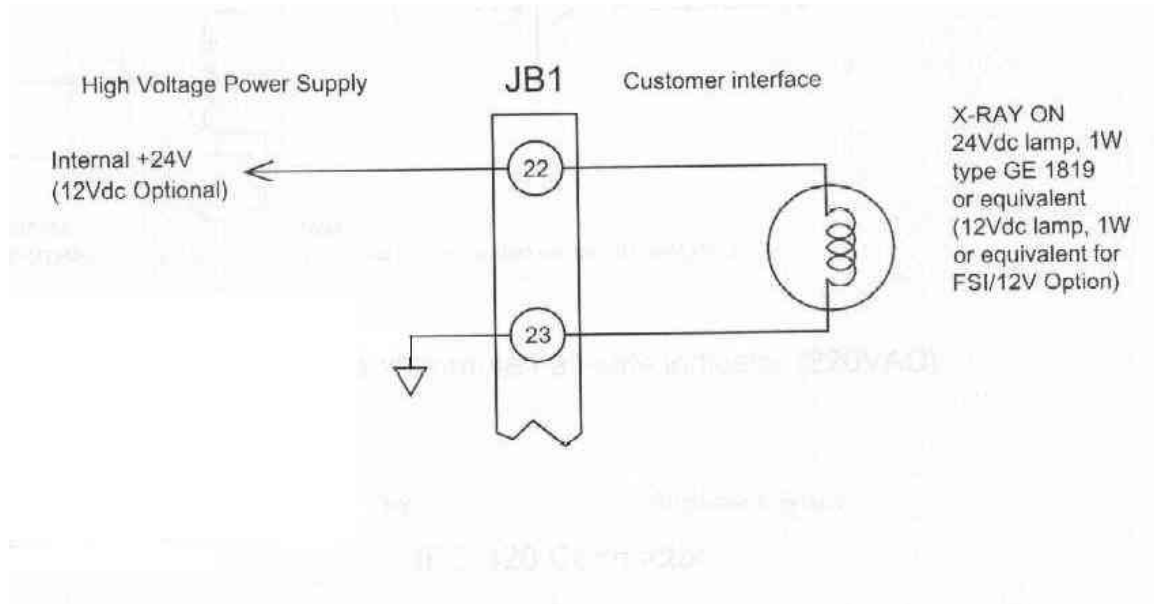
**Figure 3.6** Remote status interface

### REMOTE FAIL-SAFE X-RAY ON CIRCUITS:

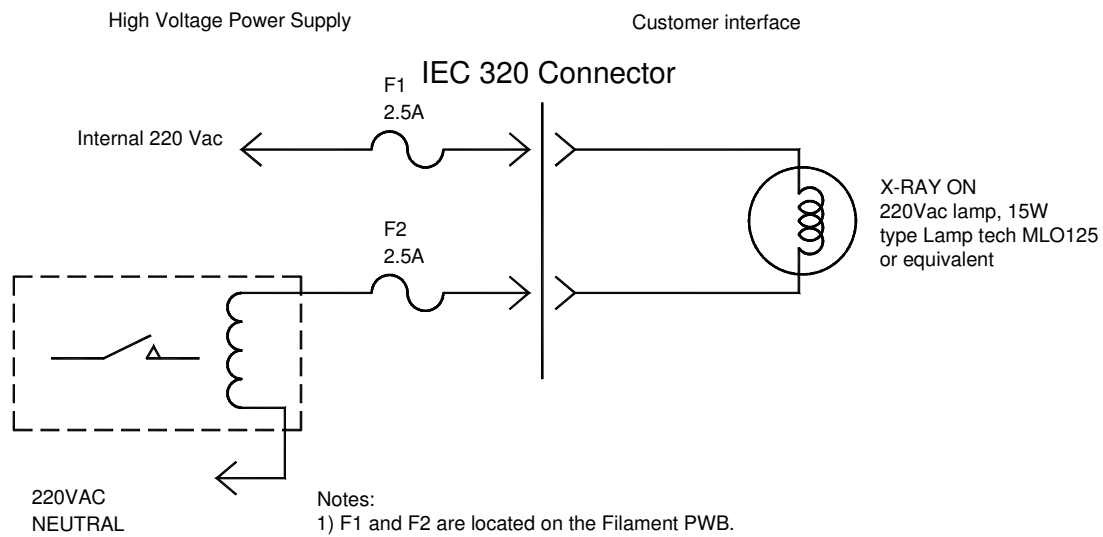
The DF/FF series provides a 24VDC circuit for a remote X-RAY ON lamp . Optional 12VDC and 220VAC lamps can be accommodated. See Figure 3.7 and Figure 3.8 for remote fail-safe connections.

### 3.2.5 REMOTE WATER SOLENOID CONTROL SIGNAL:

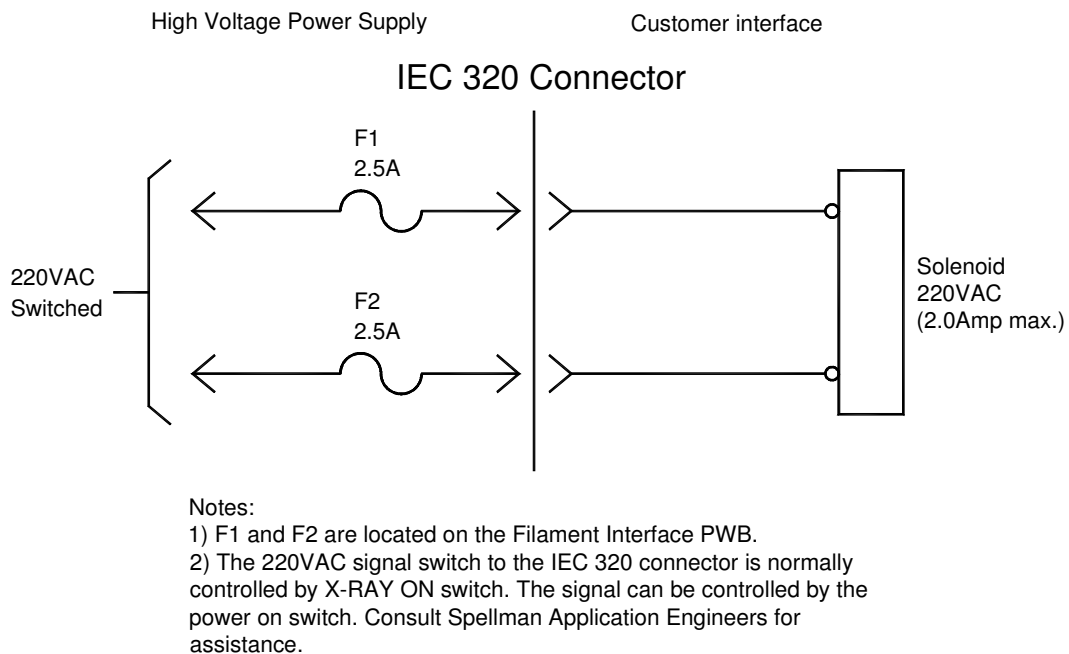
Remote signals are provided for tube water flow control and other uses. +24V and 220VAC signals are provided. These signals are switched ON when X-RAY ON is switched on. External interlock connections can also be used for water flow interlock as shown in Figure 3.9.



**Figure 3.7** Remote X-RAY ON indicator 24VDC



**Figure 3.8** Optional remote Fail-safe indicator (220VAC)



**Figure 3.9** Remote water solenoid control

**TABLE 3-1: USER INTERFACE SUMMARY**

REAR PANEL PIN	SIGNAL	REAR PANEL PIN	SIGNAL
1	Vccx ( +5v)	26	KV ref
2	cps on	27	KV com
3	Ready	28	mA ref
4	xr on	29	MA com
5	xr of	30	GND
	Not used		
6	OPTION)	31	GND
	Not used		
7	OPTION)	32	Kvreg
8	RESET	33	OL ref
9	Leakage Mon	34	Pwr limit com (OL com)
10	(+24v) (out)	35	Fil current Limit
11	Vcch (+5v out)	36	Filament current limit com
12	xon	37	mA reg
13	overvoltage	38	KV monitor
14	Kvmin	39	mA monitor
15	Overpower	40	Vcch (+5v out)
16	Fil I Limit	41	Arc
17	Overcurrent	42	KV ref mon
18		43	MA ref mon
19	PS fault	44	Vcch (+5v out)
20	GND	45	(+15v) (out)
21	Temp	46	fil current mon
	WFS (water flow switch)		
22	(OPTION)	47	fil current mon com
	WFS return		
23	(OPTION)	48	(-15v) (out)
24		49	GND
25	GND	50	open fil

## 4 PRINCIPLES OF OPERATION

The DF/FF series of high voltage power supplies utilize sophisticated power conversion technology. A variety of analog, digital and power conversion techniques are used throughout. The intention of the Principles of Operation is to introduce the basic function blocks that comprise the DF/FF power supply. For details on a specific circuit, consult Spellman's Engineering Department.

The DF/FF power supply is basically an AC to DC power converter. Within the power supply, conversions of AC to DC, then to high frequency AC, then to high voltage DC take place. By reviewing further the sub-assemblies, a basic understanding of the process can be gained.

### **WARNING:**

**The energy levels used and generated by the power supply can be lethal! Do not attempt to operate the power supply unless the user has a sufficient knowledge of the dangers and hazards of working with high voltage. Do not attempt to approach or touch any internal or external circuits or components that are connected or have been connected to the power supply. Be certain to discharge any stored energy that may be present before and after the power supply is used. Consult IEEE recommended practices for safety in high voltage testing #510-1983.**

### **4.1 LINE RECTIFICATION AND FILTERING**

Basic AC line rectification provides the DC voltage for the high frequency inverter and the filament supply.

The line input voltage can vary from 180 up to 253 volts within the series. In general, the following variations can be ordered.

200Vac  $\pm 10\%$ , 50/60Hz, 400Hz, three phase or single phase.

208Vac  $\pm 10\%$ , 50/60Hz, 400Hz, three phase or single phase.

230Vac  $\pm 10\%$ , 50/60Hz, three phase or single phase.

400Hz exceed leakage current limits.

Other input voltages can be accommodated. If the user is unsure of which input voltage option is supplied, check the serial tag on the rear of the power supply or consult Spellman Sales Department.

Circuit protection is provided by fast acting magnetic trip type circuit breaker (CB1). The line voltage is connected directly to the line side of the CB1. The load side is connected to the input of the EMI filter PWB. EMI filter reduces conducted HF noise in mains. Output of the EMI filter is connected to a contactor (K1). K1 provides fail safe type disconnection of the line voltage to power supply rectification circuit. K1 is controlled by variety of circuit conditions, which includes safety features. The output of the EMI filter is also connected to AUX transformer that provides low voltage AC power for generating auxiliary supply DC voltages.

## **WARNING**

**Line voltage is present whenever the power supply is connected to external line voltages. Be sure to disconnect the line cord before opening the unit. allow 5 minutes for internal capacitance to discharge before removing any cover.**

When K1 is energized, voltage is applied to main rectifier bridge power module CR1. Through the output of the diode module, rectified AC is supplied to filter Capacitor C1, a screw terminal type large can electrolytic. C1 is initially charged through inrush limiting circuitry located on the Filament PWB. An LC circuit comprised of HF film capacitor C2 and an air core inductor L2 filter HF noise from inverter.

### **4.2 INVERTER**

The inverter is an H bridge hybrid topology. Current mode control is used for driving the inverter. Two half-bridge IGBT modules are used as switches in H Bridge. These IGBTs provide high frequency switching to control the primary current flow. Typically they operate at approximately 18kHz.

The IGBT driver board provides the gate control of the switches. The system control board generates gate drive control signals. The IGBT gate driver PWB provides the required gate voltages and offsets.

### **4.3 HIGH VOLTAGE TRANSFORMER**

The output of the High Frequency Quasi-resonant Inverter is connected to the primary of the High Voltage Transformer. The High Voltage Transformer is a step

up type. Typical secondary voltages are in the range of 3kV to 16kV depending upon output voltage ratings.

### **4.4 HIGH VOLTAGE ASSEMBLY**

The High Voltage Assembly will vary depending upon the model ordered. The circuitry typically consists of a series arrangement of full wave voltage doublers.

A high bandwidth resistive/capacitive divider provides voltage feedback for regulation and monitoring. A sense resistor connected at the low voltage end of the High Voltage Rectifier provides current feedback for regulation and monitoring.

### **4.5 FRONT PANEL/SYSTEM CONTROL PWB**

Auxiliary DC voltages are generated in low voltage power supply section of the Front Panel/System Control PWB.

Front panel LEDs provide status indication of the necessary diagnostics needed for recognizing the operation/shutdown mode of the generator. Front panel LEDs display the following information:

CONTROL POWER ON  
EXT. INTERLOCK OPEN  
OVER VOLTAGE  
OVER POWER  
MA RGLT ERROR  
KV MIN ERROR  
FIL CURR LIMIT  
EXT INTERLOCK CLOSED  
HIGH VOLTAGE ON  
OVER CURRENT  
KV RGLT ERROR  
LEAKAGE LIMIT /TEMP  
ARC

## OPEN FILAMENT

*(Note: LEAKAGE LIMIT /TEMP LED will signal overtemp fault if light is steady, and leakage current limit if the LED is blinking)*

A precision DC 10V reference is generated on the board for programming kV, mA and other references.

Control of the generator utilizes sophisticated analog and digital circuitry resulting in fast and accurate control, protection and signaling to the user.

This generator is based on advanced PWM digitally improved control and for that purpose Unitrode UC3825 integrated circuit is used in combination with Xilinx FPGA XCS30. Analog signals are digitized in A/D converter and processed within FPGA circuits to provide maximum accuracy and reliability.

All feedback signals are sent to the user interface through digital and D/A circuits where switching is possible between feedback and program signals. This allows the user to preset the desired output before energizing high voltage.

All program voltages are typically ramped up to set level by the digital slow start.

FPGA and accompanying A-D and D-A converters and drivers provide system Fault Control and Indication. User interface is processed on this PWB as well, providing isolated relay coils, optocouplers and open collectors contact.

## 4.6 FILAMENT POWER PWB

The filament inverter provides the filament power for the X-ray tube. The filament inverter is a high frequency,

series resonant inverter. The inverter provides regulated current to the primary of the filament isolation transformer. The filament isolation transformer secondary is connected to the output connector. For the DC filament option, the transformer secondary is connected to a full wave rectifier and then to the output connector.

The filament PWB also provides variety of control, diagnostic and protection functions for AC input. One of them is inrush current limiting during initial charge of the DC rail filter capacitor. For that purpose high power limiting resistors and bypass relays are provided. Relays are controlled by sensing and driver circuitry on the same board.

If any abnormal condition appears monitoring circuitry will shut down the unit.

Neon indicator provides visual indication when DC voltage is present across the rails. This indicator should not be relied upon for confirming the presence or absence of the DC voltage. Integrated circuits provide logic control for AC faults conditions.

## 4.7 OPTIONS

Due to many variations of models and options provided in the series, details of actual circuits used may differ slightly from above descriptions. Consult Spellman's Engineering Department for questions regarding the principles of operation for the series.

## 5 OPTIONS

The options available for this power supply are described in this section. Options are specified by including the option code in the model number as described in Section 1.3.

### 5.1 208V AC THREE PHASE INPUT 3 PH

DF/FF power supplies with the 208Vac input option will operate from an input voltage of 208Vac rms  $\pm 10\%$ , 50-60Hz, three phase.

### 5.2 HIGH STABILITY HS

20ppm/ $^{\circ}\text{C}$  temperature coefficient is available for both voltage and current regulation.

### 5.3 220VAC FAIL SAFE CIRCUIT FSI (220V)

Remote Fail-Safe circuit operating at 220Vac is available. This replaces the standard WFS 220V circuit.

### 5.4 12VDC X-RAY ON INDICATOR (12V)

Remote X-RAY ON indicator circuit operating at 12Vdc is available. 24Vdc is standard.

### 5.5 24VDC WATER FLOW SIGNAL WFS (24V/PO)

24Vdc water flow signal is switched with POWER ON. The standard configuration is switched with X-RAY ON.

### 5.6 220VAC WATER FLOW SIGNAL WFS (220V/PO)

220Vac water flow signal is switched with POWER ON. The standard configuration is switched with X-RAY ON. This option is not available with FSI (220V).

### 5.7 DUAL FILAMENT SUPPLY DFS

A dual filament supply is available on DF/FF-F models only. This option allows the DF/FF-F to power Varian DTS-68 X-Ray tubes and equivalents.

### 5.8 ELAPSED TIME METER ETM

An elapsed time meter is provided. It displays cumulative hours of X-RAY ON.

### 5.9 LARGE-COMMON LC

The standard DF/FF output connections are Common = 60kV, L and S = filament output. The LC option ties L and C together and has the filament on S.

### 5.10 SLIDES SL

Units can be supplied with slides that mount into a standard EIA 10" wide rack.

### 5.11 CUSTOM DESIGNED MODELS X(#)

Units built to customer specifications are assigned an X number by the factory. If this unit is an X model, a specification control sheet is added at the end of this instruction manual.



Spellman welcomes the opportunity to tailor units to fit your requirements or to develop new products for your

applications. Contact the Spellman Sales Department with your needs.

## 6 MAINTENANCE

This section describes periodic servicing and performance testing procedures.

### **WARNING:**

**THIS POWER SUPPLY GENERATES VOLTAGES THAT ARE DANGEROUS AND MAY BE FATAL. OBSERVE EXTREME CAUTION WHEN WORKING WITH HIGH VOLTAGE.**

### 6.1 PERIODIC SERVICING

Approximately once a year, (more often in high dust environments), disconnect the power to the unit and remove the top cover. Use compressed air to blow dust out of the inside of the unit. Avoid touching or handling the high voltage assembly. Be sure that the fans are not obstructed and spin freely. The fans have sealed bearings and do not need lubrication. Be sure to replace the top cover before operating for proper cooling.

### 6.2 PERFORMANCE TEST

#### **WARNING:**

**HIGH VOLTAGE IS DANGEROUS.** Only qualified personnel should perform these tests.

High voltage test procedures are described in Spellman Bulletin STP-783, Standard Test Procedures for High Voltage Power Supplies. Copies can be obtained from the Spellman Customer Service Department. Test equipment, including an oscilloscope, a high impedance voltmeter, and a high voltage divider such as the Spellman HVD-100 or HVD-200, is needed for performance tests. All test components must be rated for operating voltage.

### 6.3 HIGH VOLTAGE DIVIDERS

High voltage dividers for precise measurement of output voltage with an accuracy up to 0.1% are available from Spellman. The HVD-100 is used for voltages up to 100kV. The HVD-200 measures up to 200kV. The Spellman divider is designed for use with differential voltmeters or high impedance digital voltmeters. The high input impedance is ideal for measuring high voltage low current sources, which would be overloaded by traditional lower impedance dividers.

# 7 FACTORY SERVICE

- 7.1 Warranty Repairs** During the warranty period, Spellman will repair all units free of charge. The warranty is void if the unit is worked on by other than Spellman personnel. See the warranty in the rear of this manual for more information. Follow the return procedures described in section 6.2. The customer shall pay for shipping to and from Spellman.

## 7.2 Factory Service Procedures

Spellman has a well-equipped factory repair department. If a unit is returned to the factory for calibration or repair, a detailed description of the specific problem should be attached.

For all units returned for repair, please obtain an authorization to ship from the customer service department, either by phone or mail prior to shipping. When you call, please the model and serial numbers, which are on the plate on the rear of the power supply, and the purchase order number for the repair. A return Material Authorization Code number (RMA Number) is needed for all returns. This RMA number should be marked clearly on the outside of the shipping container. Packages received without an RMA number will be returned to the customer. The customer shall pay for shipping to and from Spellman.

A preliminary estimate for repairs will be given by phone by Customer Service. A purchase order for this amount is requested upon issuance of the RMA Number. A more detailed estimate will be made when the power supply is received at Spellman Repair Center. In the event that repair work is extensive, Spellman will call to seek additional authorization from your company before completing the repairs.

## 7.3 Ordering Options and Modifications

Many of the options listed in chapter 5 can be retrofitted into Spellman's power supplies by our factory. For prices and arrangements contact the Spellman sales department.

## 7.4 Shipping Instructions

All power supplies returned to Spellman must be sent shipping prepaid. Pack the units carefully and securely in a suitable container, preferably in the original container, if available. The power supply should be surrounded by at least four inches of shock absorbing material. Please return all associated materials, i.e. high voltage output cables, interconnection cables, etc., so that we can examine and test the entire system.

All correspondence and phone calls should be directed to:

**Spellman High Voltage Electronics Corp**  
475 Wireless Boulevard  
Hauppauge, New York, 11788  
TEL: (631) 435-1600  
FAX: (631) 435-1620  
E-mail: [sales@spellmanhv.com](mailto:sales@spellmanhv.com)  
<http://www.spellmanhv.com>

## WARRANTY

**Spellman** High Voltage Electronics ("**Spellman**") warrants that all power supplies it manufactures will be free from defects in materials and factory workmanship, and agrees to repair or replace, without charge, any power supply that under normal use, operating conditions and maintenance reveals during the warranty period a defect in materials or factory workmanship. The warranty period is twelve (12) months from the date of shipment of the power supply. With respect to standard SL power supplies (not customized) the warranty period is thirty-six (36) months from the date of shipment of the power supply.

This warranty does not apply to any power supply that has been:

- altered, repaired or worked on by persons unauthorized by **Spellman**;
- subjected to misuse, negligent handling, or accident not caused by the power supply;
- installed, connected, adjusted, or used other than in accordance with the instructions furnished by **Spellman**.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING THOSE OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

The buyer's sole remedy for a claimed breach of this warranty, and **Spellman's** sole liability is limited, at **Spellman's** discretion, to a refund of the purchase price or the repair or replacement of the power supply at **Spellman's** cost. The buyer will be responsible for shipping charges to and from **Spellman's** plant. The buyer will not be entitled to make claim for, or recover, any anticipatory profits, or incidental, special or consequential damages resulting from, or in any way relating to, an alleged breach of this warranty.

No modification, amendment, supplement, addition, or other variation of this warranty will be binding unless it is set forth in a written instrument signed by an authorized officer of **Spellman**.

### Factory Service Procedures

For an authorization to ship, contact **Spellman's** Customer Service Department. Please state the model and serial numbers which are on the plate on the rear panel of the power supply and the reason for return. A Return Material Authorization Code Number (RMA number) is needed from **Spellman** for all returns. The RMA number should be marked clearly on the outside of the shipping container. Packages received without an RMA Number may delay return of the product. The buyer shall pay shipping costs to and from **Spellman**. For out-of-warranty repairs, the Standard Cost will be given by Customer Service. A purchase order for this amount is requested upon issuance of the RMA Number. A more detailed estimate may be made when the power supply is received at **Spellman**. If initial investigation indicates that the cost of completing the repair will exceed the Standard Cost for that unit, **Spellman** will contact the customer to authorize the repair.

### Factory Service Warranty

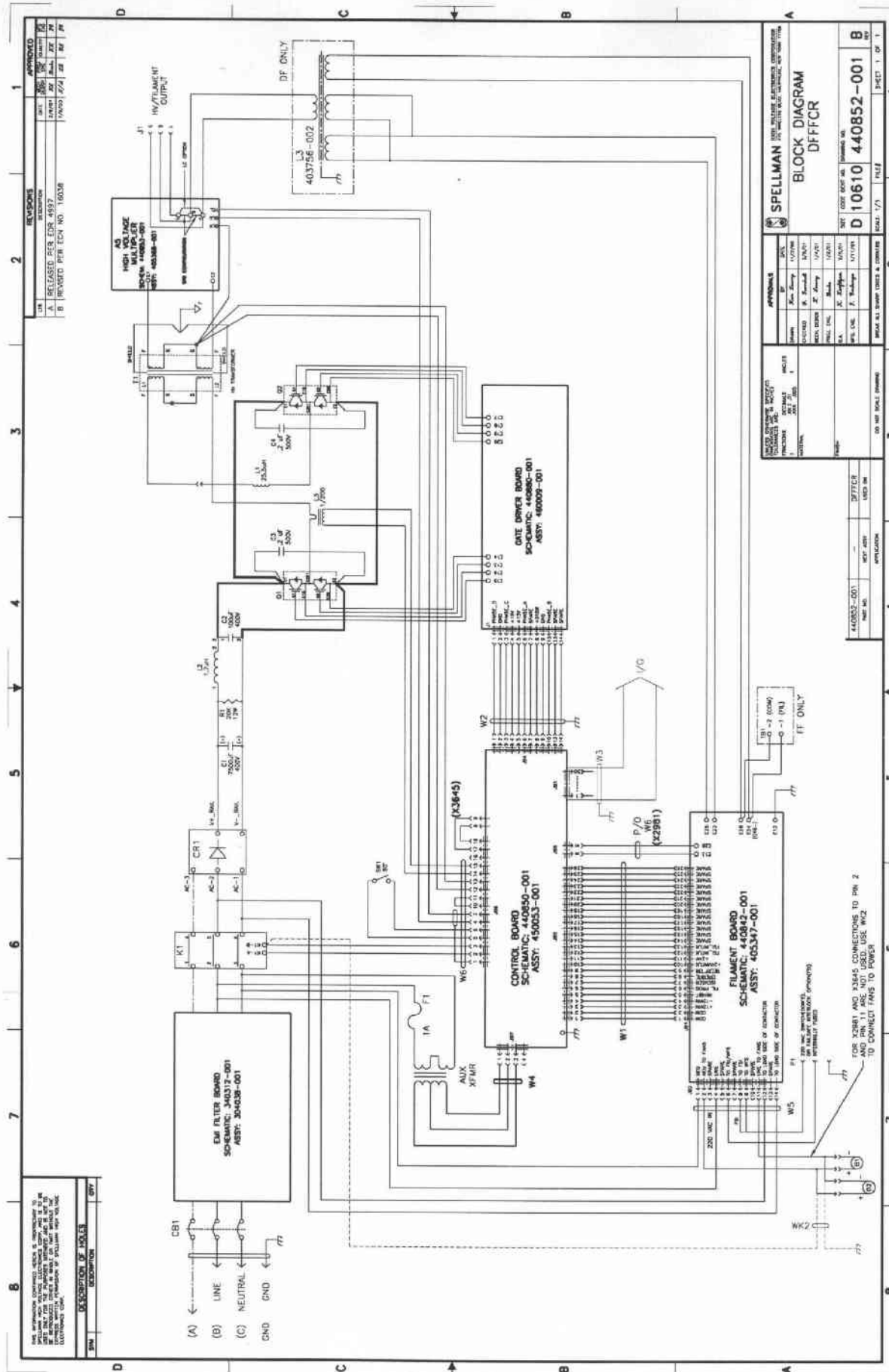
**Spellman** will warrant for three (3) months or balance of product warranty, whichever is longer, the repaired assembly/part/unit. If the same problem shall occur within this warranty period **Spellman** shall undertake all the work to rectify the problem with no charge and/or cost to the buyer.

### Spellman Worldwide Service Centers

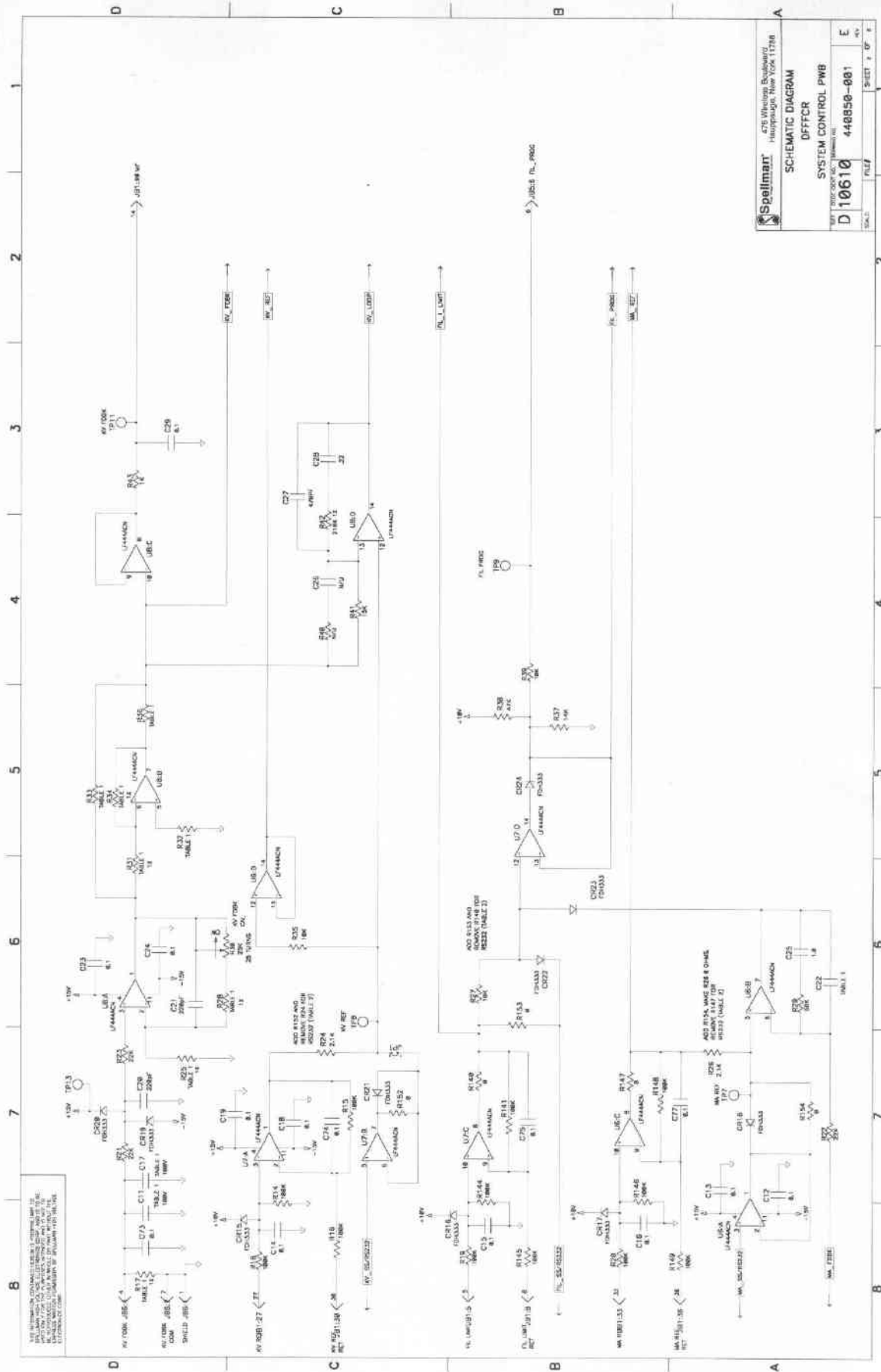
**Spellman High Voltage Electronics Corporation** • 475 Wireless Boulevard Hauppauge • New York 11788 USA • Tel: + 1 631-630-3000 • Fax: + 1 631-435-1620 • Email: [service@spellmanhv.com](mailto:service@spellmanhv.com)

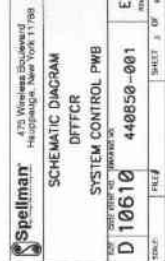
**Spellman High Voltage Electronics Limited** • Broomers Park • Broomers Hill Lane • Pulborough West Sussex • RH20 2RY UK • Tel: + 44 (0) 1798 877000 • Fax: + 44 (0) 1798 872479 • Email: [service@spellmanhv.co.uk](mailto:service@spellmanhv.co.uk)

**Spellman Japan** • 3-15 Kanayama-cho • Kawaguchi-shi • Saitama-ken • Japan 332-0014 • Tel: + 81 (0) 48-288-3222 • Fax: + 81 (0) 48-228-3224 • Email: [service@spellmanhv.co.jp](mailto:service@spellmanhv.co.jp)



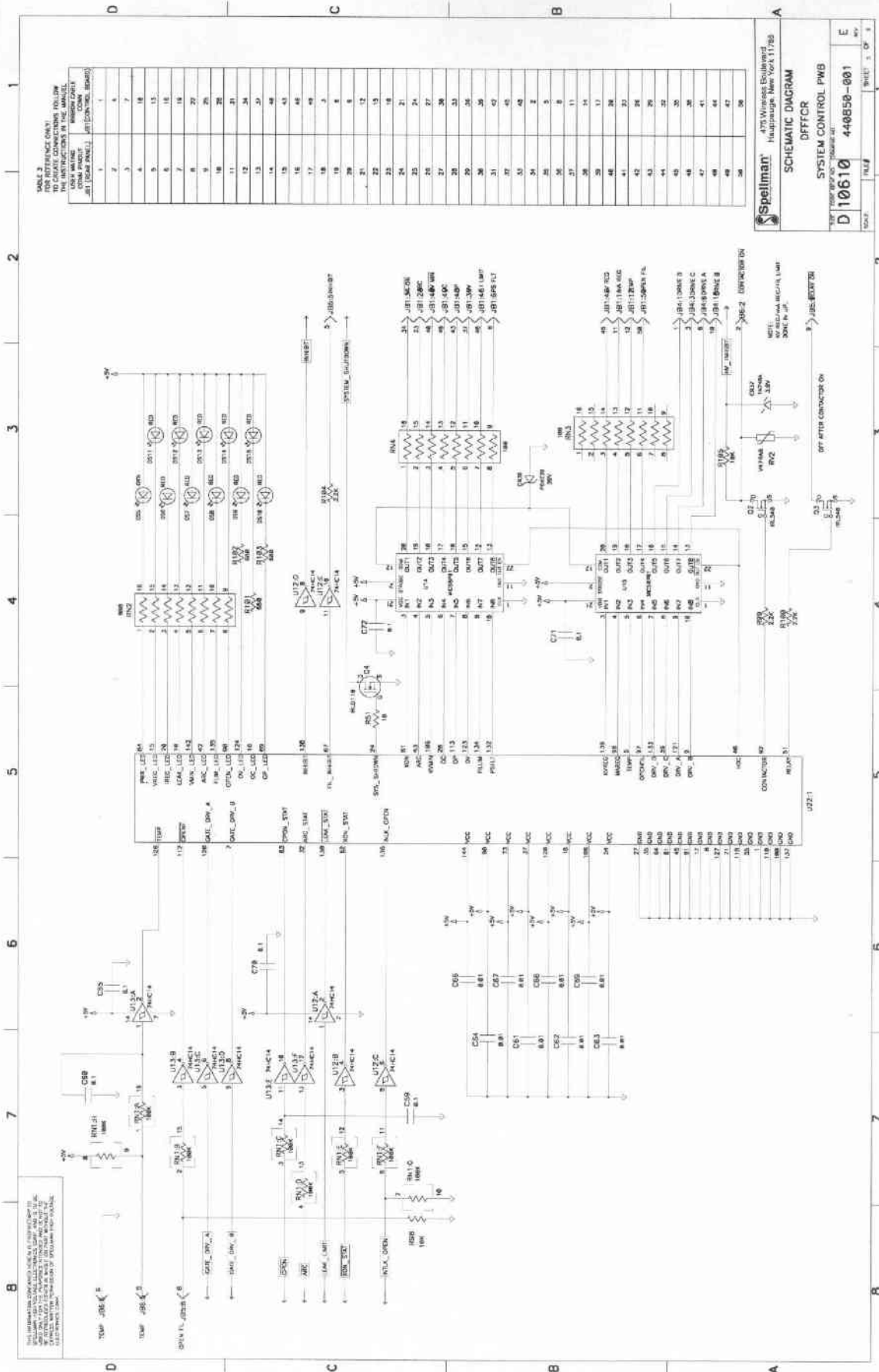


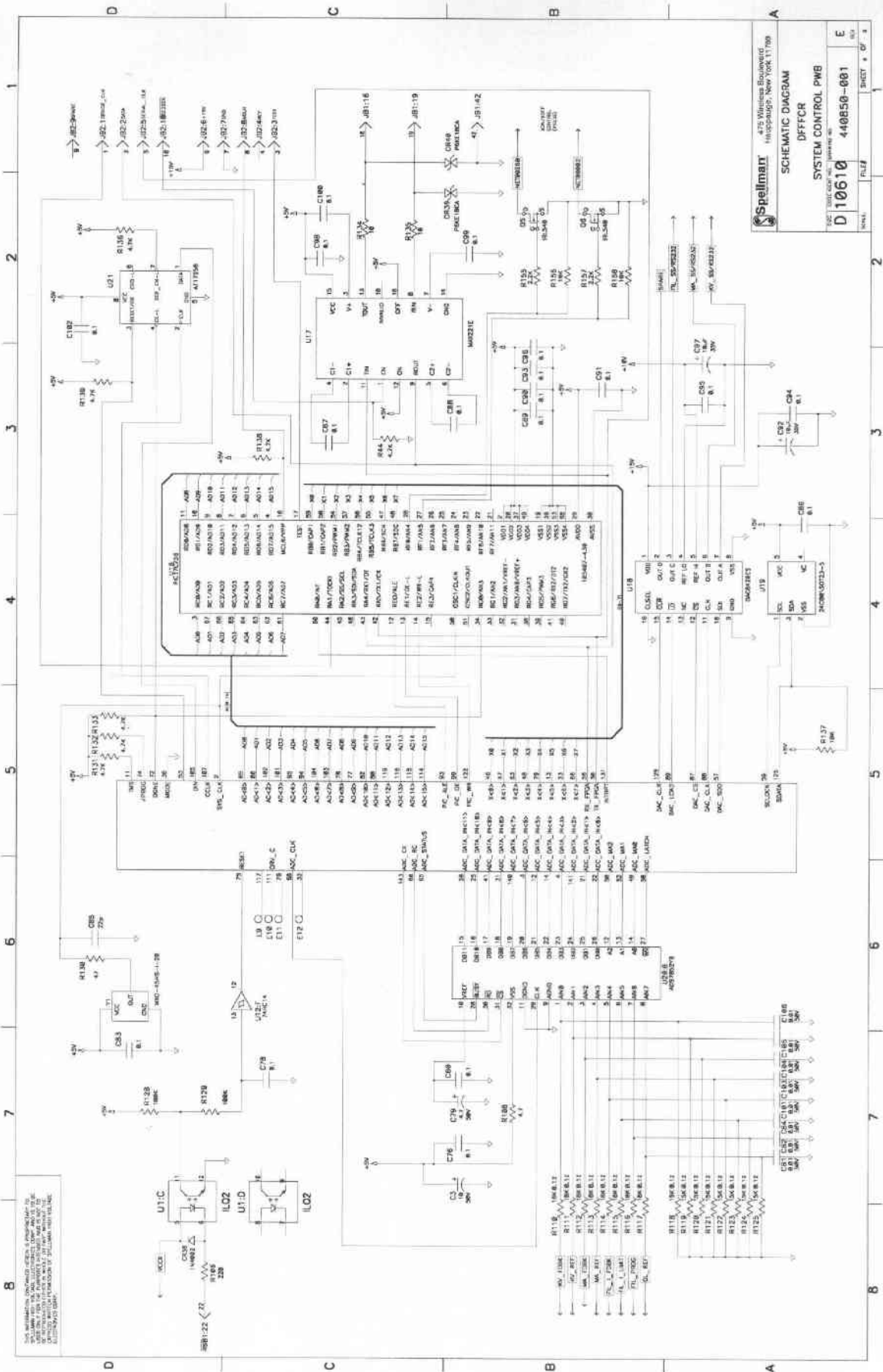


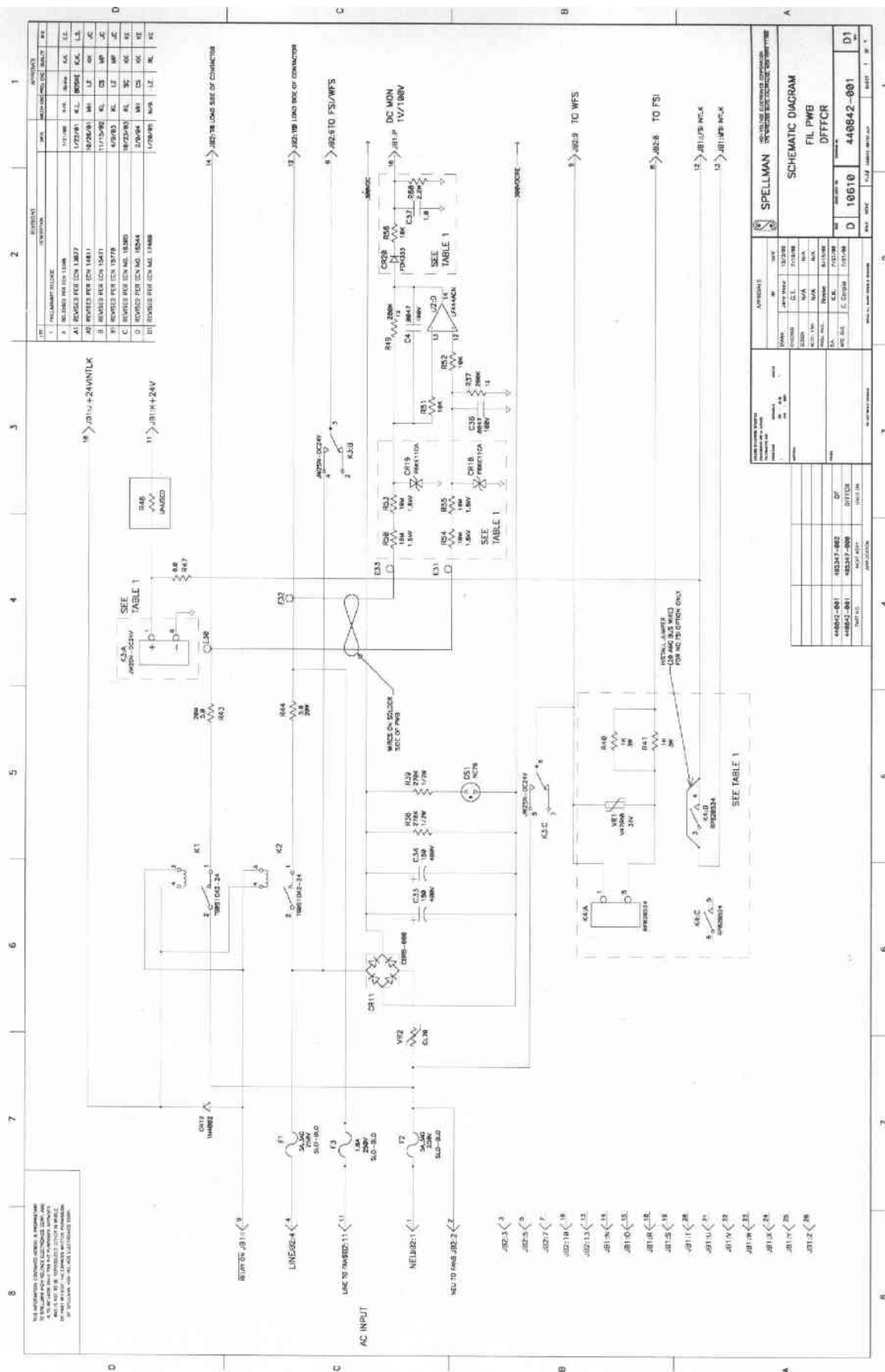
















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